Cummins Generator Technologies

Edition 6

generating insight

MARINE special edition

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AvK chosen for Chinese Surveillance Vessel

Edition 6:

Foreword

Welcome to the 6th edition of Generating Insight.

As you will have gathered from our cover, this issue of Generating Insight focuses on all things Marine. Cummins Generator Technologies has a long and successful relationship with the Marine industry, with a 50 year history of supplying alternators for almost every conceivable form of marine electrical power requirement, to virtually every region of the world; borne out by our extensive Marine compliant portfolio.

As you leaf through the pages you will find a wide range of topics, from Dynamic Positioning control of vessels through to specialist Surveillance Patrol ships. One particularly interesting article, describes the principles behind Marine Shaft Alternators and how they can be configured, not only to provide ship power, but also to improve propulsion efficiency and to provide standalone emergency propulsion in the event of a catastrophic engine failure.

The articles within this edition have been collected together to give you an 'insight' into a wide and differing aspects of the Marine industry and how electrical power generation equipment in general and Cummins Generator Technologies products specifically, are safely and efficiently incorporated into an application segment that is one of the most severe in the world, but that also demands the most stringent standards of reliability and safety in the world.

Also within this issue, we are very pleased to share the news with you that our larger range of alternators, under the AvK brand, is now UL 1004 approved. Underwriters Laboratory (UL) approval is one of the most demanding safety standards applicable to rotating electrical machines and we are extremely proud to be able to be the first alternator manufacturer to be able to offer low, medium and high voltage UL approval to our customers.

I hope you enjoy this edition of Generating Insight and that it serves its purpose in providing you with a clearer understanding of a specialist application segment, which requires tailored design solutions, intimate customer collaboration and the highest standards of safety, reliability and performance.

Dr Chris Maddison
Global Chief Engineer – Product Design

Editorial

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Generating Insight is the Cummins Generator Technologies magazine focusing on topics relevant to our products, our customers and our industry.

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AvK High Voltage Alternators **First in the World** to Achieve UL 1004-1 Safety Standard

by Alex Wheldon

AvK achieves landmark UL safety certification
AvK alternators are the first in the world to achieve UL 1004 approval for low, medium and high voltages, confirming AvK and STAMFORD products in a world-leading position.

Cummins Generator Technologies is delighted to announce that its entire AvK range of alternators from 600 to 11,000 kVA has achieved certification from UL (Underwriters Laboratories Inc.), a safety certification company well known in the US and influential globally. UL is approved to perform safety testing by the US federal Occupational Safety and Health Administration (OSHA) agency, and is on its list of Nationally Recognised Testing Laboratories. UL operates globally through offices in 46 countries around the world.

Safety certification for the AvK range means low, medium and high voltage UL approved alternators are available from Cummins Generator Technologies throughout virtually all of its STAMFORD and AvK ranges, to the benefit of customers and markets in much of the world. A UL safety certification mark on an alternator model enables OEMs to integrate them pre-approved into their generator sets.

Craiova: A world class large alternator facility
The certification applies to the AvK DIG and DSG Series, from 4 through to 10 pole configuration. “I would like to thank the Craiova team in Romania for their dedication and support throughout the approval process, from factory evaluation and compilation of the technical file, to submission of drawings, specifications and test data” says Prasant Panigrahy, Engineering Manager. “With this approval, we are the first alternator manufacturer to achieve UL 1004 approval on the full range of low, medium and high voltage synchronous products.”

Cummins Generator Technologies recently made the strategic decision to locate all of its AvK manufacturing at Craiova, Romania, to better serve customers in Europe and beyond. “UL compliance demonstrates that our products and the facility where they are manufactured are safe and meet the highest standards. It is an endorsement of our Craiova plant and its world class engineering team,” Panigrahy says.

AvK alternators produced at Craiova are already coming on-stream with their new UL certification markings in place, highlighting the quality and reliability of the product and helping to build further on Cummins’ reputation for manufacturing excellence around the world. Thanks to an investment in the latest manufacturing technologies of €12 million euros in under three years, Cummins Generator Technologies’ AvK brand alternators are making an agile and cost-effective contribution to the sub 11,000 kVA market.

AvK®

Dynamic Positioning

by Edward Letherby

As offshore exploration for oil and gas moves into deeper waters and seabed's become increasingly cluttered with pipelines etc., the anchoring of semi-submersible drill rigs/ ships and their support vessels is becoming increasingly difficult – the answer to this problem; Dynamic Positioning (DP).

DP is a computer controlled system that enables the vessel to remain on a fixed course or stay in position using the vessels thrusters and propeller units.

The system works by using a mathematical model of the vessel, combined with information gathered from position reference sensors, wind & motion sensors and gyroscopic compasses. This allows the vessels onboard computer to calculate the required steering angle and output for the rudder / propellers / thrusters.

Whilst at sea a vessel has 6 degrees of freedom; three transitional & three rotational.

Transitional

- Surge (Forward / Astern)
- Sway (Port / Starboard)
- Heave (Up/ Down)

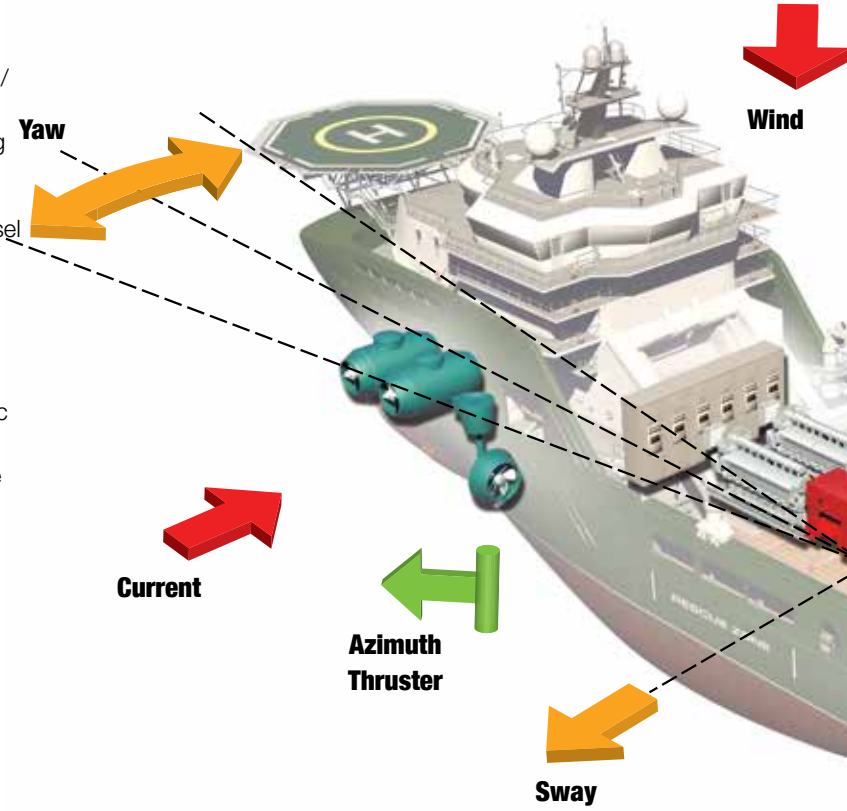
Rotational

- Roll (rotation around surge)
- Pitch (rotation around sway)
- Yaw (rotation around heave)

The DP system allows for the positioning of the vessel in either an absolute state, whereby it keeps the vessel operating DP in a locked position relative to the seabed or an oil platform, or relative to a moving object such as another vessel or an ROV (Remotely Operated Vehicle) operating beneath the surface. The DP also enables the operator to position his vessel at a favourable angle towards wind, waves and current, in a process called weather-vaning to aid the loading and unloading of the vessel at sea.

A vessel that is going to use DP needs:

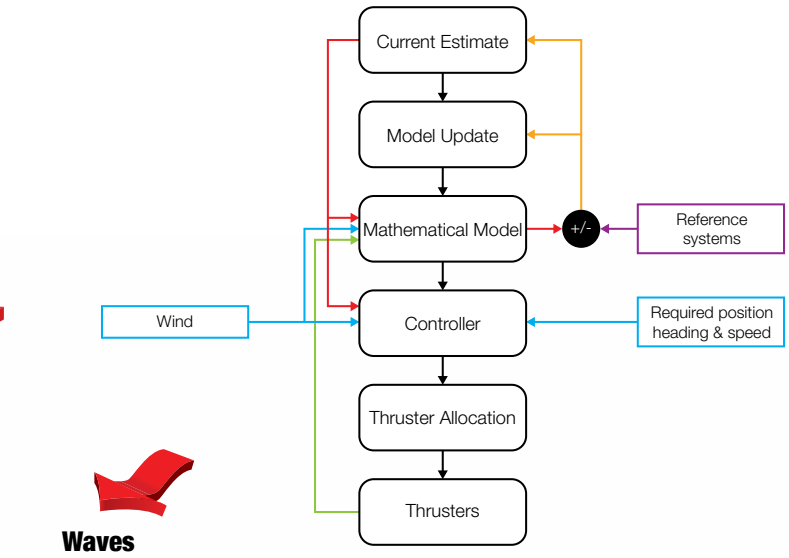
- A control computer to calculate the required control actions to maintain position and correct positional drift caused by wind, tide & current
- Sufficient thrust elements to apply the requisite forces to the vessel as demanded by the control system to maintain the position of the vessel in the face of changing weather conditions

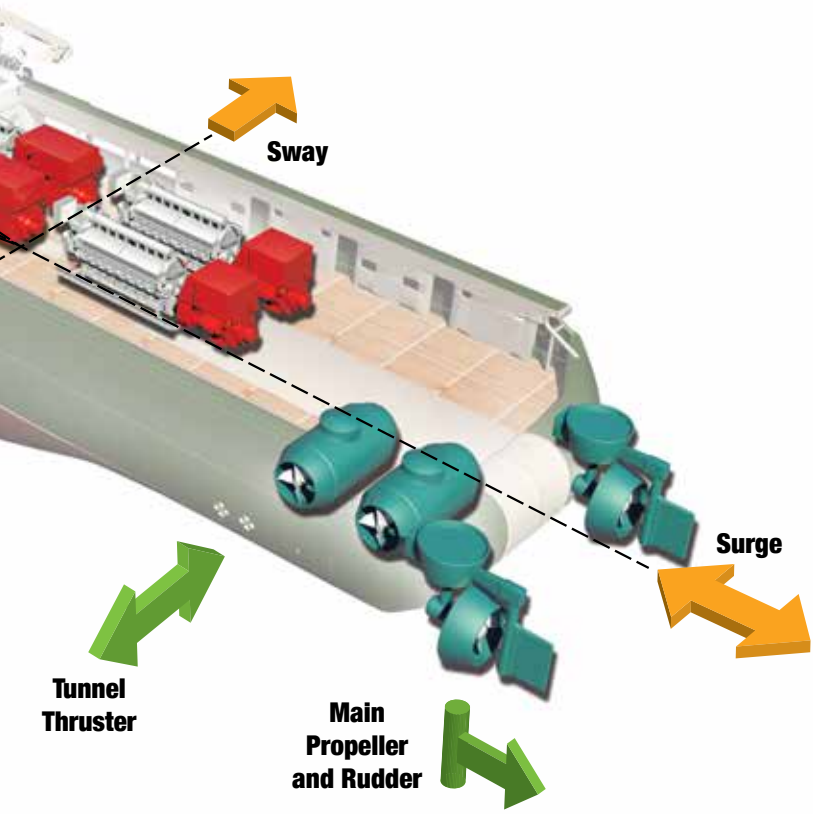


- The position reference systems and thrust elements must be carefully considered when designing a vessel with DP capability – in particular for good control of position in adverse weather conditions when operating close to another vessel / drill-rig

Under International Maritime Organisation (IMO) guidelines classification societies have issued rules for vessels utilising dynamic positioning technology described as Class 1, Class 2 and Class 3.

- Class 1 – DP system has no built in redundancy. Loss of position may occur following a single failure event
- Class 2 – DP system has redundancy so that no singular fault or failure in an active system will cause total system failure. Loss of position should not occur from a single fault in an active component such as generators, thrusters, switchboards etc., but may occur following the failure of a static component such as cables, pipes or valves





- Class 3 – Equipment has to be able to survive fire or flood in any one compartment without the system failing. Loss of position should not occur from any single failure including a fire damaged sub-division or a flooded watertight compartment

Based on this there is a guide for when vessels with differing DP classes should be used;

- DP1 – Operations where a loss of position would not endanger life, or cause damage and pollution
- DP2 – Used for operation where loss of position has the potential to cause injury, pollution or damage with major economic consequences
- DP3 – For operations where loss of position could cause fatal accidents, severe pollution and/or damage with severe economic repercussions

The differences between the DP classes are the levels of redundancy within their operating systems. Redundancy is the ability of the DP system, most commonly Classes 2 & 3, to withstand the loss of equipment which is online whilst DP operations are taking place. A single failure mode can include;

- Thruster failure
- Generator set failure
- Powerbus failure – When multiple generators are operating on one powerbus
- Control computer failure
- Position Reference System (PRS) failure
- Reference system failure

For some operations DP system redundancy is not required. An example of this would be a survey vessel losing its DP capability, there is normally no risk of damage or injury. These operations would normally be undertaken in Class 1. For operations such as diving or heavy lifting where there is a risk of damage or injury a Class 2 or 3 DP system should be used as there is multiple redundancies built into the system in the event of a failure.

In order to have sufficient redundancies there should be enough generator sets and thrusters online so that the failure of one does not cause the loss of position. The disadvantage of this is that the generator can never work at full load, to avoid this an allocation mode to the thrusters is used called ‘biasing’ in which the thrusters are set to work in pairs, counteracting each other, which allows the generators and engines to work at optimal efficiency levels.

The impact of DP to the alternator is a cyclical load profile that has the potential to change rapidly increase/ decrease the electrical loading on the alternator as the control system reacts to changes in the operational environment of the vessel.

Through the STAMFORD and AvK alternator ranges Cummins Generator Technologies has solutions that are suitable for all DP requirements.

Principles of Shaft Alternators in Marine Applications

Application overview

In marine applications, Shaft Electrical Machines (SEM's) are connected to the vessels propulsion engine and are often required to operate in a multi-function role. They operate as an alternator providing the vessels primary electrical power supply, or as an electric motor providing a short term power boost alongside the propulsion engine, or as an independent method of propulsion, when the engine is out of commission. This article sets out to give an overview of the different modes of operation and the various methods of control.

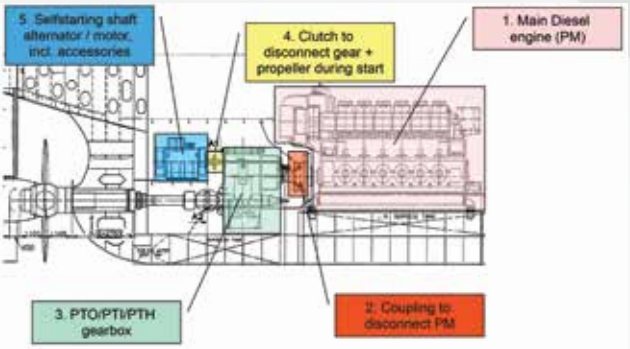


Fig.1 – A typical ship's propulsion system layout

Power Take Out (PTO)

The SEM is operating as an alternator, driven from the main propulsion engine, providing the primary power supply for the vessel electrical systems.

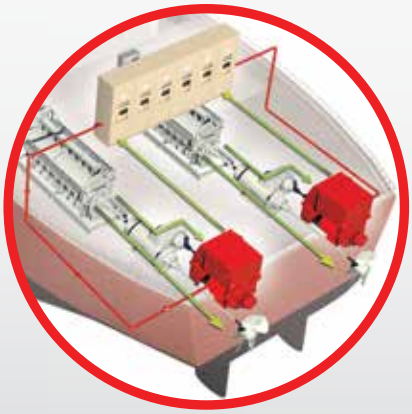


Fig. 2 – Illustration showing PTO mode

Power Take In (PTI)

Here, the SEM operates as a synchronous motor, providing a power boost, alongside the main engine to increase vessel speed, or allowing the main engine to reduce power, thereby lowering fuel consumption and wear.

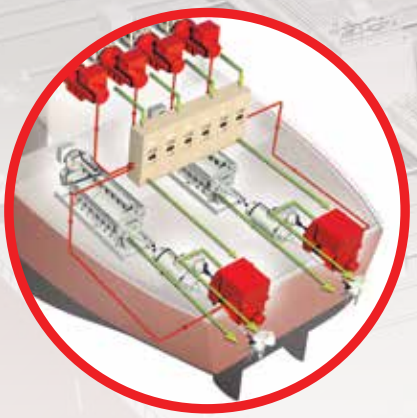


Fig. 3 – Illustration showing PTI mode

Power Take Home (PTH)

Like PTI, here the SEM operates as a synchronous motor. However, this time it provides 100% of the vessels propulsion power. This could be because the main engine has failed or requires critical maintenance or this can be a normal mode of operation, e.g. the main engine requires routine maintenance or has been stopped when the vessel is entering port. Here, SEM needs to have a self-starting capability to run up from zero speed.

Normally, this mode is required few times during the lifespan of the SEM. Therefore, an alternator is adopted for use as a motor and so will not have the robust rotor design and excitation system needed to produce sufficient torque for starting from zero speed. Consequently, a method of soft-starting has to be applied to the SEM during start up and with AvK products, some modifications are also necessary.

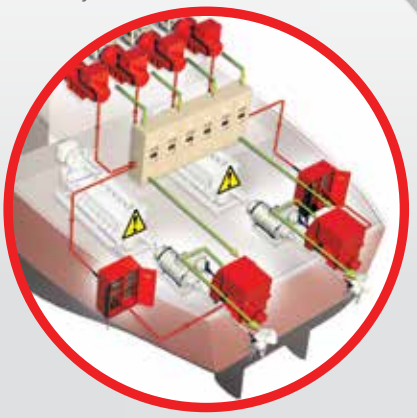


Fig. 4 – Illustration showing PTH mode

Soft-starting methods (PTH mode only)

There are different methods to start the SEM in the PTH mode. The following explains five well-known solutions:

1 Pony motor start

The SEM shaft is connected and driven to speed by a small electric motor, which then disengages once synchronous speed is achieved.

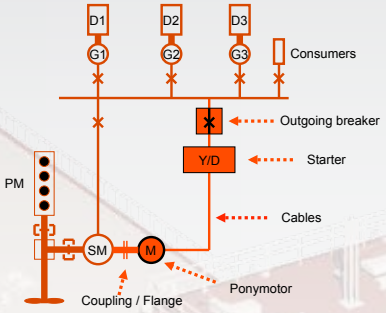


Fig. 5 – Line diagram showing Pony motor start method

2 Auto-Transformer start

Here, an auto-transformer reduces the voltage supplied to the SEM, thereby restricting the inrush current, whilst still ensuring that sufficient breakaway torque is available to turn the shaft.

The SEM starts as an asynchronous motor and therefore, requires some modifications to the excitation system of the machine.

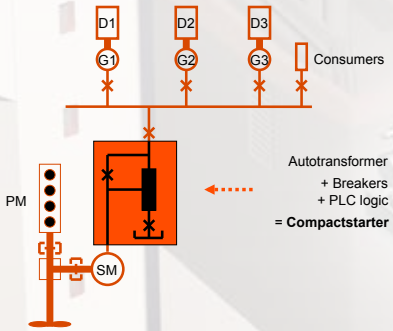


Fig. 6 – Line diagram showing Auto-transformer start method

3 Excitation controlled start (single propeller)

Here the inrush current is limited by using a Stator Current limiting feature on the AVR of the auxiliary alternators.

Again, the machine starts asynchronously and so requires some excitation system modifications.

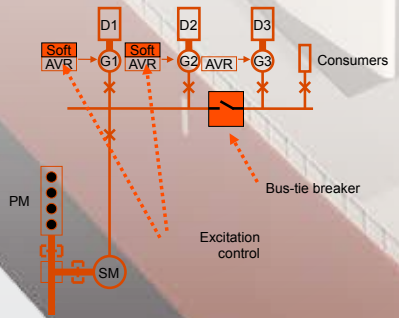


Fig. 7 – Line diagram showing Excitation start method for single SEM

4 Excitation controlled start (twin propeller)

This is similar to 3). However, here the vessel has twin propellers, twin engines and two SEM's. The Stator Current limiting capability is present on each SEM, allowing one (operating in PTO mode) to start the second (operating in PTI/PTH mode).

With two identical SEM's, it is possible to swap the PTO and PTI/PTH modes from one to the other.

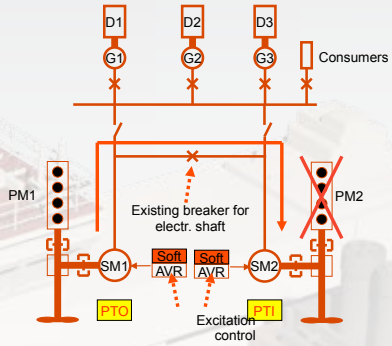


Fig. 8 – Line diagram showing Excitation start method for twin SEM

5 VFD start

Here the SEM is controlled through a VFD which ramps up the machine shaft, ensuring the current is limited but the correct amount of torque is delivered. The machine can be started as a synchronous motor. This system can also be applied to twin propeller vessels.

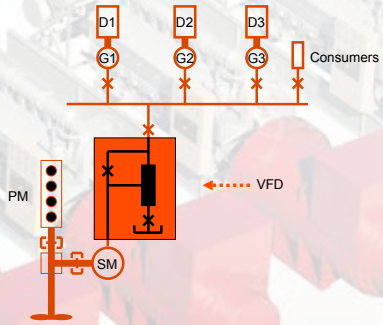


Fig. 9 – Line diagram showing VFD start method

Cummins Generator Technologies have suitable products for all the modes of operation and control methods detailed above, not only for the shaft electrical machines, but also for the auxiliary alternators, as well.

MARINE CERTIFICATION

by Simon Walton

Alternators used in many marine applications require certification in accordance with a marine classification society. A marine classification society creates and maintains technical standards for the construction and operation of ships and offshore structures. Ship classification verifies the structural strength and integrity of essential parts of the ship's hull and appendages, also the reliability and function of the power generation and other auxiliary equipment that have been built into the ship to maintain essential services on board. This provides ship builders and owners with the confidence that their vessels are designed and built to a high standard with regards to safety and reliability. The classification societies' are non-governmental organisations. It is the responsibility of the society to set technical rules and confirm that the designs and calculations meet them.

Cummins Generator Technologies have the capability to provide alternators in compliance with many marine societies' as shown below:

The International Association of Classification Societies (IACS) was formed in formed in 1968, enabling collaboration between Classification Societies. This created a combined level of technical knowledge and experience between 12 major classification Societies. The formation of IACS has resulted in a common ruleset with the marine industry.

Cummins Generator Technologies have Test Cell facilities in all of our manufacturing plants to carry out marine type test approval testing which can also be witnessed if required.

A typical marine survey comprises of the following:

- Traceability of materials used
- Verification of technical data in accordance with the specification
- Confirmation of maintenance and calibration of test equipment
- Verification of asbestos-free declaration
- Review of supporting documentation
- Full alternator performance testing including; insulation resistance, winding resistance, voltage regulation, voltage transient, open/short circuit characteristics, excitation current, temperature rise, overload capacity, short circuit capacity and overspeed capability.

Cummins Generator Technologies have type approval for certain marine societies which avoids the need for marine inspectors to inspect every marine alternator that we manufacture. This helps reduce lead time and inspection charges.

Cummins Generator Technologies have Test Cell facilities in all of our manufacturing plants to carry out marine type test approval testing

Marine Enclosures

by Simon Walton

Cummins Generator Technologies offer a wide range of alternator enclosures to suit different environmental operating applications. This article provides an overview of typical enclosures used within the marine industry.

Open Ventilated

Open ventilated air cooled alternators rely on the surrounding ambient air to provide their cooling requirements. A shaft mounted fan circulates cooling air through the alternator from the surrounding environment. As a consequence of this, they can be limited by the level of ingress protection that can be offered. Most typically, an open ventilated alternator will not offer better than an IP2x rating, when it comes to solid object ingress, although with some specialist air filtration equipment it is possible to raise this to a IP4x level. The fitting of air filters to an IP23 rated alternator will very often incur a de-rate of the electrical output of the alternator, due to the potential restriction in airflow caused by the filters elements.

As for water ingress, typically IPx3 is acceptable for most industrial applications. For marine alternators there are more complications mainly due to the requirements of Safety Of Life At Sea (SOLAS), where there is often a need for a water sprinkler, or spray system to be located directly over the generator set. As a consequence the IP rating is often raised to IPx4. In open ventilated alternators, again this can be accomplished with special air filtration techniques. Although more often the ship designer will opt for a totally enclosed alternator solution.

Totally Enclosed

Totally enclosed alternators are usually specified when the alternator is to operate in a harsh environment, where there are high levels of water and/or dust content in the surrounding ambient air. The internal areas of the alternator are completely sealed from the outside. Air inside is circulated by a conventional, shaft mounted fan, but instead of pulling in and expelling external air, it passes through an alternator-mounted cooler, which contains a heat exchanger connected to an external coolant. Typically, this external coolant could be air or water. The temperature of the air inside the alternator (primary coolant circuit) is maintained according to the cooler's rating and the predetermined temperature of the externally connected coolant (secondary coolant circuit).

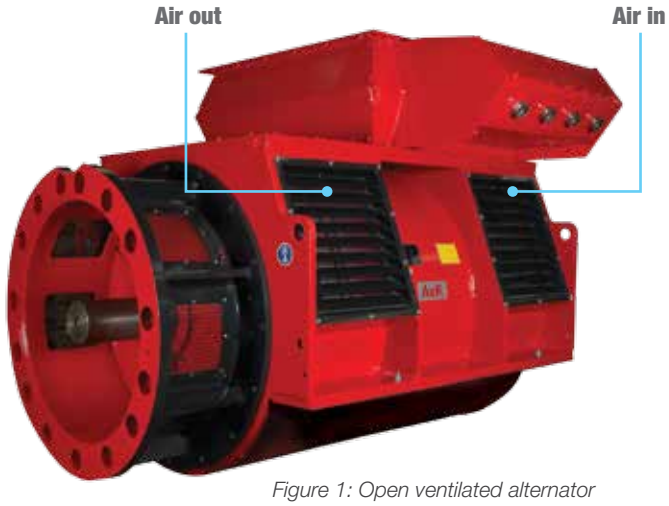


Figure 1: Open ventilated alternator

Totally enclosed water cooled (CACW)

A cooler box is mounted on the alternator, usually on top. Inside, cooled water is pumped through a matrix of elements (secondary coolant circuit). Air circulating around the internal (windings) area of the alternator (primary cooling circuit), cools as it passes over the elements, before re-entering the winding section of the alternator.

After taking heat from the air, the water is cooled to a defined temperature by external systems and returned to the cooler box. Because the temperature differential between the returning water and air is known, it is possible to calculate the size of cooler required and therefore, the electrical output rating of the alternator.

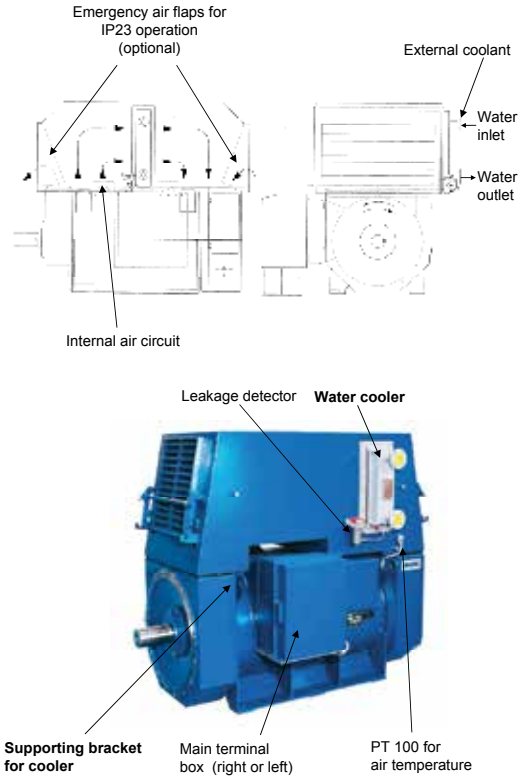


Figure 2: Totally enclosed, water-cooled (CACW)

Totally enclosed, air-cooled (CACA)

As with a water cooled totally enclosed alternator, this method also utilises a top mounted cooler box. Inside the cooler there are rows of pipes along its length which form the secondary coolant circuit. Air from an external source is blown through these pipes at a predetermined temperature.

Air can be blown through these pipes using an electric fan supplied by an external power source or by an additional mechanical fan driven by the alternators main shaft.

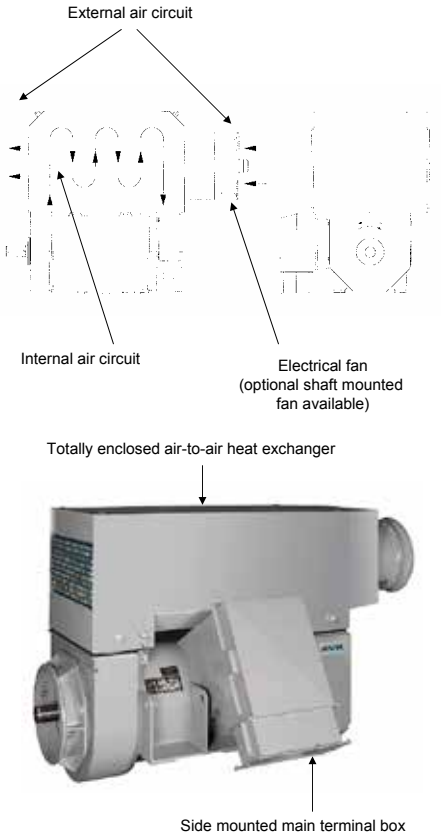


Figure 3: Totally enclosed, air-cooled (CACA)

AvK DSG 114 Powers Chinese Surveillance Vessel

by Qiwen Qian

Background

Under international laws, the territorial waters around China operate under the Chinese Mare Clausum or 'Closed Sea' dictate, which means that the waters are not accessible to other states. Because of this, there is an increasing demand for Marine Surveillance vessels. The main function of a surveillance vessel, in accordance with the relevant laws and regulations, is to implement cruise surveillance in the waters under national jurisdiction (including coastal zones).

The load on these vessels is variable and therefore the power system is critical in achieving the vessel's mode of operation.

Why AvK was chosen

China Marine Surveillance (CMS) and the power system design engineer specified four key requirements:-

- Twin propeller vessel requiring Power Take Off (PTO)/ Power Take In (PTI)/ Power Take Home (PTH) mode of operation
- Size – physical space for alternator is limited
- Reliability - simple system is required
- Easy to maintain

AvK have a unique solution for PTH known as "excitation controlled start". This is a simple, smart alternator-motor start solution. This solution negates the need for any additional auxiliary components or a complex control system.

The China Applications Engineering team worked in collaboration with CMS and the power system design engineer to provide a cost effective solution.

Starting method	Advantage	Disadvantage	Remark
Ponymotor	■ Lowest starting currents ■ Easy engineering	■ Additional breaker for ponymotor ■ Additional space / length ■ Low pull-up torque ■ Long starting time	■ Starter for ponymotor can be placed were suitable
Autotransformer	■ No additional breaker in main switchboard ■ No length increase ■ Strong pull-up torque ■ Shorter starting time	■ Higher starting current ■ Additional space ■ More engineering needed	■ Autotransformer / Compact starter can be placed where suitable
Excitation-control (Single propeller)	■ No length increase ■ Strong pull-up torque ■ Shorter starting time ■ Easy engineering ■ PTH system fully isolated from consumers ■ No maintenance	■ Additional bus-tie breaker in main switchboard needed ■ Less flexibility / redundancy	■ With splitted mains busbar only ■ Higher flexibility with double busbar system
AvK Electric shaft (Twin propeller)	■ No length increase ■ Strong pull-up torque ■ Shorter starting time ■ Easy engineering ■ No maintenance		■ Twin propeller vessels only ■ Easiest self-start system for twin propeller vessels ■ Can be used for low speed / manoeuvring mode

Table 1. Starting Methods

Vessel Mode of Operation

The vessel is operated in three modes of operation - cruise, full speed and emergency.

Cruise Mode of Operation

In this mode the surveillance vessel runs at low, stable speed. During this mode of operation the power system runs in eco mode with one DSG 114K1/4 working in PTO and the other in PTI mode.

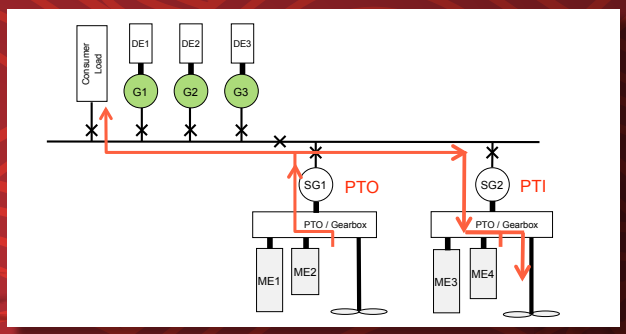


Figure 1: Cruise Mode of Operation

Full Speed Mode of Operation

In this mode the surveillance vessel runs at high speed (>20 Knots) and therefore maximum output power is required.

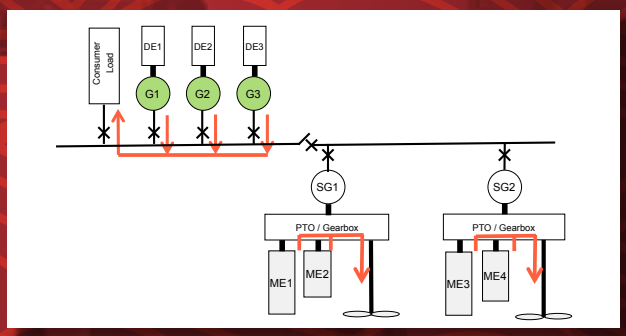


Figure 2: Full Speed Mode of Operation

Emergency Mode of Operation

In emergency situations, where one side of the main engines fails (eg. ME3 & ME4), one of the DSG 114K1/4(SG1) operates in PTO mode and the other (SG2) in PTH mode (self-start and driven by the propeller). This enables the vessel to return to port.

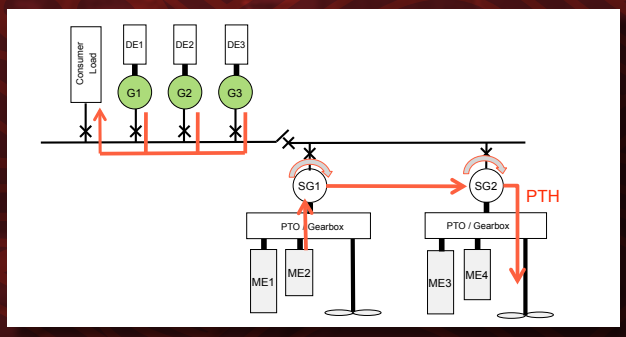


Figure 3: Emergency Mode of Operation

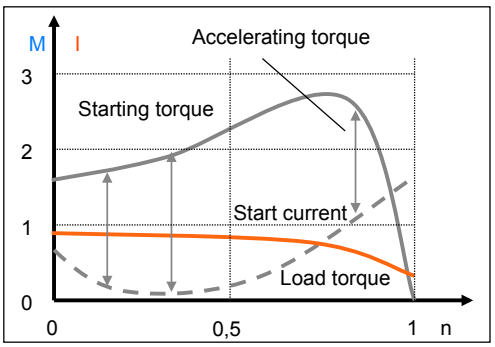
Summary

Having the opportunity to hold successful, open communication sessions with the ship owner, ship yard, power system design engineers and suppliers of other components was key in providing a reliable, effective solution.

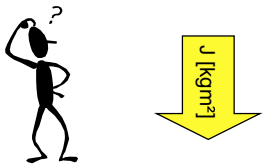
Communication with the ship owner to understand the vessels modes of operation enabled us to easily understand the requirements and effectively communicate the advantages of the AvK product with the power system design engineers.

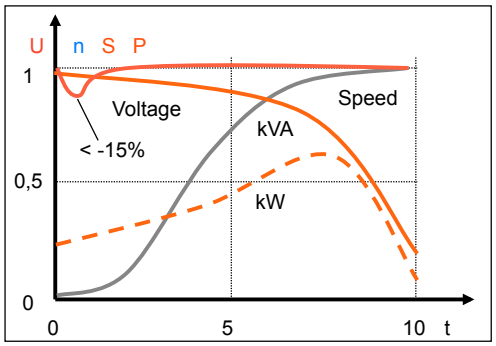
Working with the suppliers of other components also helped to interpret the system designer's requirements in order to deliver the solution.

Having a global support network from internal teams such as Applications and Product Engineering also provided a forum to discuss and share previous experience of similar applications.



Starting torque, load torque and start current vs. PTH speed.





Starting kVA, starting kW and PTH speed vs. time.

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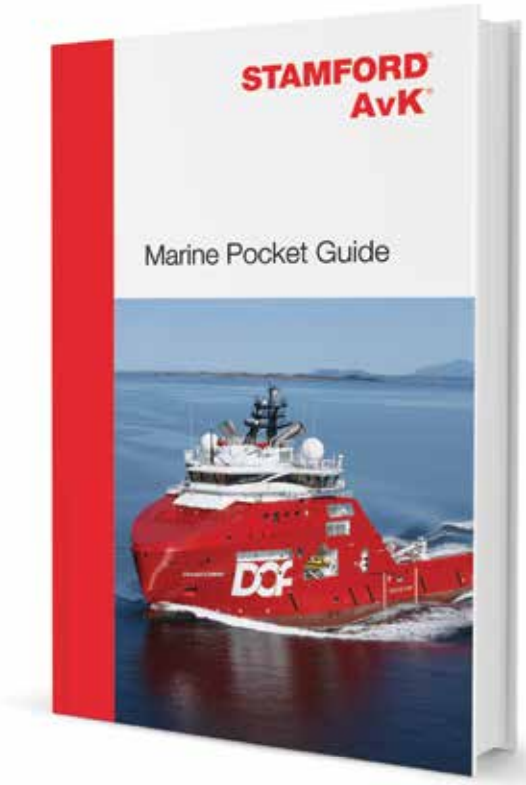
Now Available

Technology leaders in alternator design and manufacture, Cummins Generator Technologies has a proven track record of delivering dependable power to the marine market. With over 50 years of experience serving the marine industry, customers benefit from a comprehensive range of premium alternators under the globally recognised STAMFORD and AvK brands.

In the Marine Pocket Guide you'll find technical information on all of our STAMFORD | AvK marine alternators, as well as highlights from an assortment of AvK references from over the years, spanning complex power requirements across many interesting vessel types, ranging from Offshore to Fishing Vessels.

We believe this collection represents our capability to best serve the toughest and most critical electric power applications of them all – marine.

For a copy of the Marine Pocket Guide contact your sales manager.



Also available, the STAMFORD | AvK marine video - *Proven Marine Power* watch it now at YouTube.com/stamfordavk

NOW AVAILABLE

Customer in Focus

AvK® alternators provide power in VARD's hybrid marine system

Customer: VARD

Where: Søvik, Norway

Specified: 2 x AvK DSG 144 alternators
3 x AvK DSG 114 alternators

Purpose: Hybrid power for the newly constructed Skandi Iceman offshore vessel

When the hybrid power system for a customer's new oil and gas offshore support vessel required alternators, it was a natural decision for VARD to specify AvK. Over many years, VARD has come to rely on the Cummins Generator Technologies sales, order handling and application engineering teams for their high level of technical knowledge and quick response to requirements. On this project, VARD were impressed with a particularly swift response in support of final contract negotiations with VARD's end customer, DOF Subsea. VARD won the contract, which was to supply the onboard hybrid power system for the Skandi Iceman, to be built at the Vard Søviknes shipyard in Norway. DOF Subsea's new Anchor Handling Tug Supply (AHTS) vessel is designed for offshore operation in the oil and gas sector.

In addition to the features of conventional platform supply vessels, AHTS vessels have winches for towing and anchor handling, and an open stern that allows anchors to be brought on deck.

The Skandi Iceman is designed to be deployable worldwide, and able to operate continuously in order to pay back its investment. The vessel's specification called for high speed, low fuel consumption, excellent manoeuvrability and stability. VARD ensured the overall power system achieved the internationally recognised DNV certification, while DNV Green Passport accreditation was provided by Cummins Generator Technologies. DOF Subsea called for a number of modifications, which VARD and Cummins Generator Technologies collaborated on and successfully delivered. The automatic voltage regulator had to be in a separate box from the alternator, while a custom redesign of the alternator's external dimensions was required to fit into limited space in the machining room. Other bespoke work included oil supply and oil cooling of sleeve bearings, plus the locations of water connections and of power cable entry. The system benefits from IP44 enclosure protection with an air/water heat exchanger. Because of the vessel's deck machinery and its Diesel Electric Propulsion (DEP) capability, including tunnel thrusters and acipod thruster, the power system had to be able to handle high load steps.

And because the vessel would have to operate in heavy seas, its power system had to be rugged enough to cope with the demands of a harsh marine environment. The Skandi Iceman has now entered service in the North Sea with all its design requirements met by a power solution built around five alternators.

Two AvK DSG144n/10W alternators function as shaft alternators for non-propulsive power – "Hotel power" in marine terminology – and also for propulsive hybrid power. Three auxiliary generator sets fitted with AvK DSG 114M1/8W alternators deliver power for the DEP system while manoeuvring, as well as power for deck machinery and the vessel's FiFi I+II specification fire-fighting pumps. Between them, the two 5,500 kVA DSG 144 alternators and the three 3,000 kVA DSG 114 alternators meet the vessel's 20,000 kVA total power requirement.

For more information on Cummins Generator Technologies' AvK range of alternators visit:
www.stamford-avk.com

generating insight

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